(12) UK Patent Application (19) GB (11) 2 178 934 A

(43) Application published 25 Feb 1987

(21) Application No 8507546

(22) Date of filing 22 Mar 1985

(51) INT CL[4]
A01B 79/00 A01C 21/00 A01D 91/00

(52) Domestic classification (Edition I):
A1D 2
A1B C
A1F JA
G3N 281B 281X 286A 286C 383X GA
U1S 1005 1006 A1B A1D A1F G3N

(56) Documents cited
None

(58) Field of search
A1D
A1B
A1F
G3N
Selected US specifications from IPC sub-classes A01C
A01B A01D

(71) Applicant
Massey-Ferguson Manufacturing Limited,

(Incorporated in United Kingdom),

33 Davies Street, London W1Y 2EA

Dronningborg Maskinfabrik A/S,

(Incorporated in Denmark),

Box 80, 8900 Randers, Denmark

(72) Inventors
Jens Overgård,
Jan Peters
Dennis Anthony Colvin

(74) Agent and/or Address for Service
D. Bryn Jones, Massey-Ferguson Patent Department,
Stareton, Nr Kenilworth, Warwickshire CV8 2LJ

(54) Agricultural husbandry

(57) The location of mobile agricultural equipment is identified in a field and is related to a husbandry process value that varies as the equipment traverses the field, the location either being recorded in conjunction with the process value to produce a map of the process value in the field, or being used to determine said process value by reference to a map of the process value in the field. The husbandry process value may comprise a crop yield measurement made during harvesting so as to produce a map of crop yield in the field, or the result of an agricultural husbandry examination carried out when traversing the field so as to produce a map of examination results in the field, or the value of an arable husbandry treatment incorporated in a predetermined treatment map of treatment values for many locations in the field so as to derive a corresponding treatment value for each location.

GB 2 178 934 A

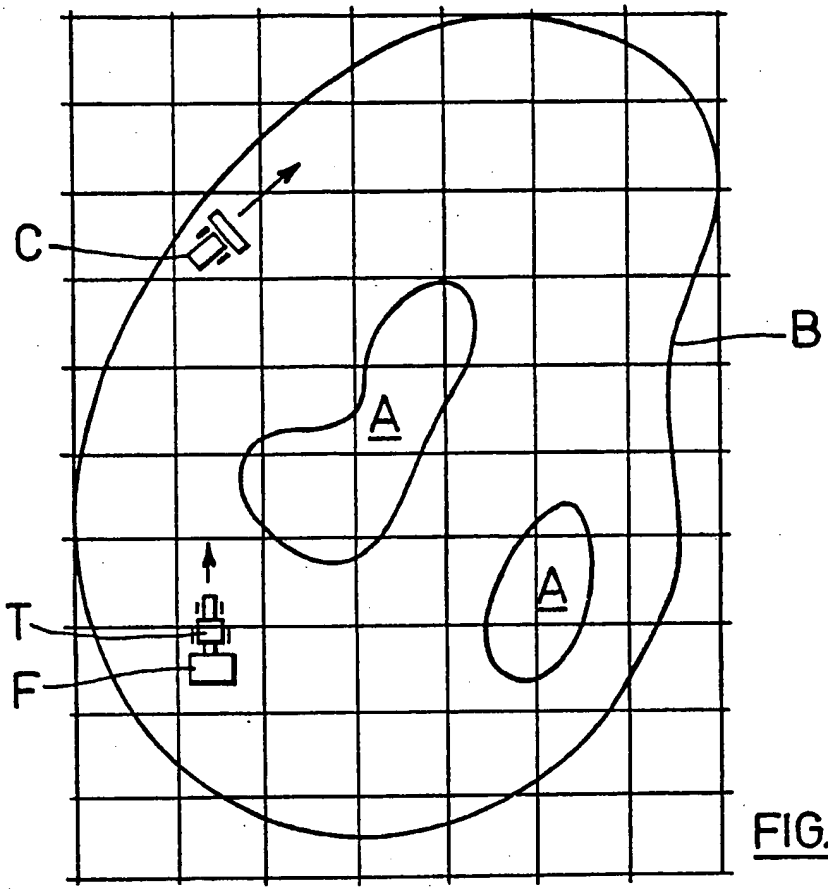

FIG.1

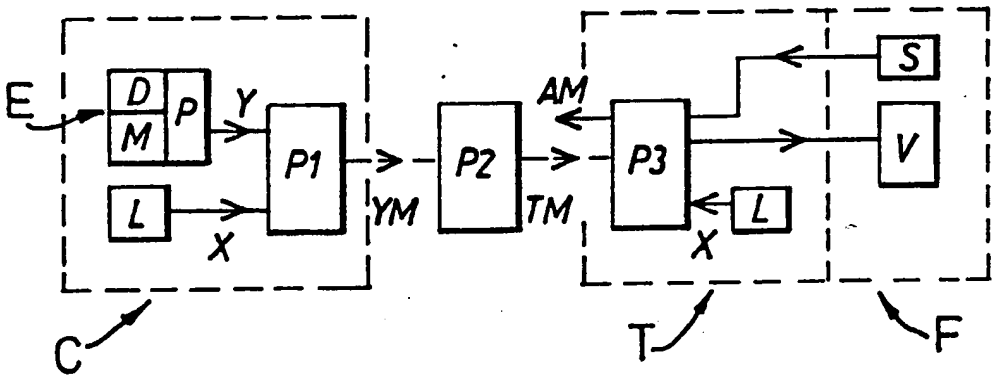

FIG.2

SPECIFICATION

Agricultural Husbandry

Technical Field

This invention relates to agricultural husbandry processes and means for carrying out these processes.

Modern farming is heavily dependent on the use of chemicals such as fertilizers, herbicides and pesticides for increased crop yield and crop quality. Many different chemicals are available to suit different crops and field conditions and advice services are available to help the farmer. The objective of the farmer is to increase the value of his crop, and thus the financial benefits of chemical treatments have to be carefully assessed and compared with their costs. Over-treatment is wasteful and may even have an adverse effect. For example, over-treatment with fertilizer causes lodging of the crop and leaves residues in the soil. On the other hand, under-treatment can be ineffective, especially when treating disease and pests. Close control of the application rate of chemical treatments is therefore important, but is made very difficult when field conditions can vary widely, requiring different chemical application rates. Present treatment practices involve the selection of an optimum application rate within any particular field and this is maintained constant. There is therefore likely to be a degree of waste and possibly damage caused by chemical treatments even when the optimum application rate is selected.

In order to assess the effect of chemical treatments on cereals, devices have been provided for combine harvesters to measure the amount of crop harvested and area covered so that crop yield can be measured and related to the chemical treatment the crop has received. These devices allow the farmer to make comparative tests and make his own judgement on future chemical treatments for the field as a whole, but this does not help to overcome the problem of variable field conditions.

An object of the present invention is to provide improved agricultural husbandry processes and equipment that will give the farmer better control of chemical crop treatments.

Disclosure of the invention

The invention is based on the fact that once the location of mobile agricultural equipment is identified in a field, this can advantageously be related to a husbandry process value that varies as the equipment traverses the field, the location either being recorded in conjunction with the process value to produce a map of the process value in the field, or being used to determine said process value by reference to a map of the process value in the field.

The word map should be taken to mean a record of values and associated spatial locations capable of being depicted as a two dimensional array (e.g. on a sheet of paper), though not necessarily so depicted. It may, for instance, consist of a succession of values recorded electronically.

The husbandry process value may comprise a crop yield measurement made during harvesting so as to produce a map of crop yield in the field, or the result of an agricultural husbandry examination carried out when traversing the field so as to produce a map of examination results in the field, or the value of an arable husbandry treatment incorporated in a predetermined treatment map of treatment values for many locations in the field so as to derive a corresponding treatment value for each location.

It will be readily appreciated that a crop yield map is a useful tool that allows a farmer to decide on subsequent husbandry treatment in that field. For example, low yield in one part of the field may be remedied by selective treatment of that part of the field with fertilizer in a subsequent season. A yield map can therefore be interpreted and used to form a corresponding treatment map, and this may be conveniently done using a suitably programmed data processor.

Similarly, a map of examination results derived from examination of the field can be used to form a corresponding treatment map. The examination may take the form of a test such as a soil test, and the results may be automatically recorded in relation to the location of the test site, or an operator may carry out a visual inspection (e.g. for pests) and derive the results from a personal assessment.

Once a husbandry treatment map is available, this can be used directly to control a treatment process according to the location of mobile treatment equipment in a field so that the treatment is varied as desired to suit each part of the field. For example, a field may have identified low spots which are high in humus and require less fertilizer than the rest of the field. A treatment map can therefore be produced and used to control the application rate of fertilizer in the field, thereby avoiding harmful over-treatment of the low spots or under-treatment of the surrounding higher ground.

The treatment map may divide the field into a plurality of adjoining patches of predetermined size and shape, and a treatment value associated with each. The movement of the treatment equipment across the boundaries between adjoining patches is then detected and used to set the treatment value for the next patch to be treated.

The location of equipment in the field is preferably determined by location means carried on the equipment and operating with reference to independent datum means. For example, the location means may take the form of a radio receiver and data processor and the datum means may comprise a plurality of satellites emitting radio signals that are detected by the radio receiver and used to determine the location of the equipment.

A combine harvester can readily be fitted with such location means, a yield measuring device, and recording means to record successive yield measurements in conjunction with the corresponding locations of the combine for each measurement, thereby forming a grain yield map.

Also, agricultural treatment equipment can readily be fitted with the same location means and programmable control means that is responsive to location information from said location means in accordance with a predetermined treatment programme so as to identify the treatment value for the equipment as it traverses the field.

Description of the drawings

The invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 shows a schematic plan of a field that is subjected to cereal husbandry processes according to the invention, and

Figure 2 is a schematic representation of monitoring and control apparatus that is used in conjunction with a combine harvester and a fertilizer distributor in carrying out the invention.

Best mode of carrying out the invention

Figure 1 shows a field with a boundary B in which a cereal crop is grown. At harvest time, a combine harvester C is used to harvest the crop by traversing the field in a systematic manner, for example, by driving round the periphery of the field and moving inwards to make successive circuits, or by making a plurality of parallel passes across the field. The route taken by the combine is not relevant to the invention.

A yield monitor E is provided on the combine comprising a device M that continuously measures the amount of grain harvested as it is delivered to the grain tank of the combine and a device D that measures the distance travelled by the combine and thus gives a measure of the area harvested for a combine table of predetermined width. These two measurements are processed in a data processor P to produce a yield measurement Y. (i.e. the amount of grain harvested/unit area) in any part of the field during harvesting. An example of a yield monitor device is disclosed in British Patent No. 2087704.

The distance measuring device D takes the form of a transducer that produces pulses in response to rotation of the drive wheels of the combine so as to produce a number of pulses corresponding to the distance travel. This device D is also used to trigger periodic readouts of the yield measurements Y and these are recorded in a data processor unit P1 that is provided on the combine.

Location means L is also provided on the combine that can give a reading X of the location of the combine in the field at any time. This may take the form of a radio receiver and data processor unit that receives and decodes radio signals from a plurality of space satellites. Such systems are known and are already in use for marine navigation purposes, for example, as supplied by Polytechnic Marine PLC. Alternative location means may employ fixed radio beacons or a radar system or an inertial direction sensing system.

The location means L has an input to the data processor unit P1 and the latter operates so that each time it records a yield measurement Y, it also records the current location reading X. Therefore, as the combine harvests the crop, the data processor unit P1 records a map of yield measurements throughout the field. By way of example in Figure 1, some parts of the field marked A have a lower yield than the rest, and this is reflected in the yield map.

In an alternative arrangement, the data processor P1 can use successive readings X from the location means L to determine the distance travelled by the combine, thereby making it unnecessary to provide the separate distance sensing device D. The distance to be travelled by the combine in determining a yield measurement is pre-selected, and a successi n of such distances along the path of the combine may be defin d by the location of the boundaries between them. The data processor P1 then simply detects the movement of the combine across each of these boundaries in turn and triggers completion of one yield measurement and commencement of the next.

In yet another alternative arrangement, the grain measuring device M may continuously measure the rate at which grain is harvested and delivered to the grain tank of the combine. A suitable device is disclosed in International Application No. 85/00087. The speed of the combine is also monitored so that the crop yield at any instant is given by the ratio of the grain harvesting rate and the speed of the combine. The speed can be determined by a separate sensor, such as a radar sensor unit, or by using the readings from the location means and a timer to compute speed in the data processor P1.

The record of the yield map is removable from the data processor P1 on a portable memory unit which is used in a second data processor P2 to form a treatment map. This second data processor P2 is located at the farm office or the office of an agricultural husbandry advice service. As a preliminary step in producing a treatment map, the yield measurements are processed in data processor P2 to form a modified yield map which is based on a pre-selected square array of treatment areas shown superimposed on the field plan in Figure 1. An average yield value is calculated for each square treatment area using the measurements taken at field locations within this area. The location of each square treatment area is identified either by reference to its boundary co-ordinates, or by reference to its centre co-ordinates which in turn define the boundary co-ordinates for a predetermined size of treatment square.

The modified yield map is then converted into a treatment map using a cereal husbandry programme that converts each average yield value into a corresponding treatment value. This programme is compiled based on well established husbandry principles and may be similar to programmes already available to advise farmers on arable husbandry processes. Typically, the treatment concerned is fertilizer application, and the programme converts the average yield values into corresponding fertilizer application rates. In the illustrated example, a proportionately higher fertilizer application rate is prescribed for the areas A of the field with lower yield values. A record of the treatment map TM is removable from the data processor P2 on a portable memory unit for use in a third data processor P3 to control the rate of fertilizer application by a fertilizer distributor F.

The fertilizer distributor F is shown in Figure 1 mounted on the rear links of a tractor T and has an adjustable control mechanism V to vary the fertilizer application rate. The tractor T is provided with the data processor P3 and carries location means L which conventionally is the same as that provided on the combine C. The tractor and fertilizer distributor combination T, F traverses the field B in a systematic manner so as to treat the whole field, but the route

chosen may be different to that taken by the combine harvester C in the previous season's harvest. The setting of the fertilizer rate control mechanism V is determined by the data processor P3 by reference to the treatment map TM and the readings X of the location of the tractor in the field so that each square treatment area has fertilizer applied to it at the corresponding rate recorded on the treatment map.

In particular, the data processor P3 makes use of the location readings X and the boundary co-ordinates of the array of treatment areas in the treatment map TM to detect when the tractor crosses the boundary from one treatment area into the next and then determines the appropriate setting of the control mechanism V for the next treatment area. Thus every time the tractor T crosses a boundary into a particular treatment area, the fertilizer application rate is set to the predetermined optimum setting for that area. In the example in Figure 1, the predetermined higher fertilizer rates will be applied in those treatment areas over parts of the field marked A.

The control mechanism V may be controlled directly by a control signal from the data processor P3 or may be controlled by the tractor driver in response to readings produced on a visual display unit operated by the data processor P3.

The actual treatment applied to the field by the fertilizer distributor may be monitored independently of the control mechanism V, for example, by using a fertilizer flow sensor S so as to give an accurate measure of the actual treatment. These measurements can be taken for each square treatment area and recorded in the data processor P3 together with the corresponding location reading for each treatment area so as to produce a map of AM of the applied treatment. A record of this map AM can be removed from the data processor P3 on a portable memory unit for future reference.

As described above, the yield map YM is modified in the data processor P2 by superimposing on it a rectangular array of square treatment areas and averaging the yield measurements that occur within each treatment area. However, this step may not be necessary if each yield measurement is made over a large enough area which is then designated as a treatment area. The treatment areas are then necessarily the same width as the table of the combine, but may be as long as required. The subsequent treatment process is then such that the same width or a sub-multiple of this width is treated in one pass, and the treatment equipment follows along the same passes as the combine.

As described above, the treatment map TM is produced from a yield map YM but treatment maps produced in other ways can equally well be used in the data processor P3 to control the treatment process. For example, the tractor T can be driven across the field B and a direct assessment made of the value of a treatment process needed for each part of the field and recorded in conjunction with the location information from the location means L. As before these treatment values can be presented on a rectangular array of square treatment areas. The treatment values may be derived from an actual test carried out on the soil or crop, or may simply be an assessment based on a visual inspection.

In another embodiment of the invention, instead of using the data processor P2 to produce a treatment map, the record of the yield may YM is loaded directly into the data processor P3 on the tractor T and is used to d termine appropriate treatment values according to the location of the tractor as the treatment proceeds. The data processor P3 uses the tractor location reading to select the corresponding yield measurements for that part of the field that is about to be treated. The selected measurements are those that lie within the treatment width for a predetermined distance ahead of the actual treatment process and these are averaged to give an average yield value that is constantly updated as the tractor traverses the field. The average yield values are then converted into corresponding treatment values are then converted into corresponding treatment values by the data processor P3 using the husbandry programme that is now loaded in the data processor P3 instead of data processor P2. As before, the treatment values are then used to determine the setting of the treatment control mechanism V.

The yield map could be replaced by maps based on other field examination results that are used with the appropriate husbandry programme in the data processor P3 to produce treatment values.

Alternatively, a treatment map may be loaded into the data processor P3 in place of the yield map and husbandry programme, and treatment values are taken directly from this map and averaged to produce a control signal for the control mechanism V.

Furthermore, although the invention has been described above in relation to the application of fertilizer for a cereal crop, it is applicable to a wide range of husbandry processes for a range of crops. For example, the application of insecticides and pesticides can readily be controlled in a similar manner. Drills and planters with a variable sowing rate can also be controlled according to a predetermined plant population map for optimum plant development in different parts of the field. Cultivators, such as ploughs with a variable depth setting, can also be controlled according to a predetermined cultivation map.

Yet further, the invention should not be thought of a being confined for use with vehicles which are in contact with the ground. The invention is clearly suitable and adaptable for rapidly varying the rate at which a helicopter or other airborne vehicle carrying a location means might treat a growing crop by spraying or dusting.

CLAIMS

1. An agricultural husbandry process which is carried out by mobile agricultural equipment traversing a field and in which a corresponding process value varies, characterised in that the location of the equipment is monitored and either recorded in conjunction with the process value to produce a map of the process value in the field, or used to determine said process value by reference to a map of the process in the field.

2. A process as claimed in claim 1 in which said equipment is mobile harvesting equipment in which the amount of crop harvested is measured as harvesting proceeds and is recorded as said process value.

3. A process as claimed in claim 1 in which said equipment is mobile agricultural treatment equipment carrying out a treatment process in which said process value is a treatment value that is varied as the equipment traverses the field.

4. A process as claimed in claim 1 in which a husbandry examination process is carried out and the examination result recorded as said process value.

5. An agricultural husbandry process in which mobile harvesting equipment harvests crop in a field and measures the amount of crop harvested as harvesting proceeds, characterised in that the position of the equipment in the field is monitored and a crop measurement is monitored and recorded in conjunction with the location of the equipment at which the crop is harvested so as to produce a map of the amount of crop harvested in different parts of the field.

6. A process as claimed in claim 5 in which the amount of harvested crop is measured for each of a succession of patches of the field and used to produce a crop yield measurement for each patch which is recorded in conjunction with the location of each patch.

7. A process as claimed in claim 6 in which the locations of the boundaries between adjoining patches are detected and used to determine the area of each patch for the yield measurement.

8. A process as claimed in claim 5 in which following said harvesting operation a treatment process is carried out by mobile treatment equipment that traverses the field and varies a treatment value in accordance with the location of said treatment equipment in the field and by reference to said crop measurements.

9. A process as claimed in claim 8 in which said crop measurements that exist in locations across the treated width of the treatment equipment and in a predetermined distance ahead of the actual treatment process are averaged and used to determine the treatment value.

10. A process as claimed in claim 9 which the treatment value is continuously updated as the treatment equipment traverses the field.

11. A process claimed in claim 8 in which said crop measurements are used to determine a treatment value for each of a plurality of locations in the field so as to produce a treatment map, and in which the treatment value is varied by reference to said treatment map.

12. A process as claimed in claim 11 in which said crop measurements are used to calculate a total crop measurement for each of an array of patches of the field of predetermined size, shape and location, and a treatment value corresponding to the total crop measurement is ascribed to each patch of the field so as to produce a treatment map, the treatment value in the subsequent treatment process being varied in accordance with the location of the patch being treated and by reference to said treatment map.

13. A process as claimed in claim 12 in which the locations of the boundary between adjoining patches is detected and used to set the treatment value associated with the next patch to be treated.

14. A process as claimed in any one of claims 8 to 13 in which a data processor is used to produce the treatment values fr m said crop measurements.

15. A process as claimed in any one of claims 8 to 10 in which the treatment pr cess carried out by the trteatment equipment is controlled by a data processor according to a programme incorporating said crop measurements.

16. A process as claimed in any one of claims 11 to 13 in which a treatment process carried out by the treatment equipment is controlled by a data processor according to a programme incorporating said treatment map.

17. A process as claimed in any one of claims 5 to 16 in which a data processor is used to record the crop measurments and corresponding locations to produce the crop map.

18. An agricultural husbandry process in which mobile equipment traverses a field and carries out a treatment process characterised in that a treatment value of the the treatment process is varied in a predetermined manner in accordance with the location of the equipment in the field.

19. A process as claimed in claim 18 in which successive patches of the field of predetermined size, shape and location are treated each in accordance with a predetermined treatment value associated with that patch.

20. A process as claimed in claim 19 in which the location of the boundary between adjoining patches is detected and used to set the treatment value of the next patch.

21. A process as claimed in claim 20 in which the location of the boundary between adjoining patches automatically sets the treatment value of the next patch.

22. A process as claimed in claim 21 in which the location of the boundary between adjoining patches triggers a display of the treatment value of the next patch so that the equipment operator can set the treatment value of the next patch.

23. A process as claimed in any one claims 18 to 22 in which the variable treatment value associated with the treatment process is measured as the treatment is carried out and is recorded in conjunction with the location of the equipment in the field to produce an applied treatment map of the field.

24. An agricultural husbandry process in which mobile equipment traverses a field characterised in that as the husbandry process is carried out corresponding process results are recorded in conjunction with the location of the equipment in the field so as to produce a map of process results in the field.

25. A process as claimed in claim 24 in which the husbandry process is carried out in successive patches of the field of predetermined size and location and a corresponding process result recorded for each in conjunction with the location of each respective patch.

26. A process as claimed in claim 25 in which locations of the boundaries between adjoining patches are detected and used to determine the process result to be recorded.

27. A process as claimed in any one f claims 24 t 26 in which following said husbandry process a treatment process is carried out by mobile treatment equipment that traverses the field and varies a treatment value in accordance with the location of said

equipment in the field and by reference to said process results.

28. A process as claimed in claim 27 in which said process results that exist in locations across the treatment width of the treatment equipment and in a predetermined distance ahead of the actual treatment process are averaged and used to determine the treatment value.

29. A process as claimed in claim 28 in which the treatment value is continuously updated as the treatment equipment traverses the field.

30. A process as claimed in claim 27 in which said process results are used to determine a treatment value for each of a plurality of locations in the field so as to produce a treatment map, and in which the treatment value is varied by reference to said treatment map.

31. A process as claimed in any one of claims 24 to 30 in which the husbandry process comprises an examination process in which crop or soil in the field is examined.

32. A process as claimed in any one of claims 5 to 31 in which the location of the equipment in the field is determined by location means that operates by direct reference to independent datum means.

33. A process as claimed in claim 32 in which the datum means comprises a plurality of satellites emitting radio signals that are detected by said location means on the equipment.

34. An agricultural husbandry process in which mobile agricultural equipment traverses a field in carrying out a husbandry process and in which the area covered by the equipment is measured, characterised in that the location of the equipment in the field is monitored to obtain information of successive locations of the equipment, which information is processed to determine the area covered by, or the velocity of the equipment.

35. A process as claimed in claim 34 in which the equipment carries out a harvesting process and in which the amount of crop harvested is measured and processed to produce a crop yield measurement.

36. Mobile harvesting equipment fitted with measuring means to measure the amount of crop harvested, characterised in that it is also fitted with location means to identify the location of the equipment in a field, and recording means to record measured values of the amount of crop harvested and the corresponding locations of the equipment when harvesting said amounts of crop so as to produce a map of the amount of crop harvested in different parts of the field.

37. Equipment as claimed in claim 36 in which the location means identifies the location of the boundary between adjoining patches of the field, and the recording means is responsive to operation of said location means and measuring means to record the value of the amount of crop harvested in each patch of the field as it is harvested.

38. Equipment as claimed in claim 36 in combination with a data processor adapted t analyse the values of the amount of crop harvested and corresponding location information recorded in said recording means and to compute a treatment value for each of a plurality of locations in the field, thereby pr ducing a treatment programme.

39. Equipment as claimed in claim 38 in which the data processor is adapted to calculate a total crop measurement for each of an array of patches of the field of predetermined size, shape and location, and to compute a corresponding treatment value for each patch.

40. Equipment as claimed in claim 38 or 39 in combination with mobile agricultural treatment equipment comprising treatment apparatus that is adjustable to vary a treatment value, location means to identify the location of the equipment in a field, and programmable control means that is responsive to operation of said location means in accordance with said treatment programme produced by the data processor, thereby to determine the treatment value for the treatment apparatus as it traverses the field.

41. Equipment as claimed in claim 36 or 37 in combination with mobile agricultural treatment equipment comprising treatment apparatus that is adjustable to vary a treatment value, locations means to identify the location of the equipment in the field, and programmable control means that is responsive to operation of said location means in accordance with a programme incorporating said map of the amount of crop harvested so as to compute the treatment value for the treatment apparatus as it traverses the field.

42. Equipment as claimed in any one of claims 36 to 41 in which the location means operates by direct reference to independent datum means.

43. Equipment as claimed of claim 42 in which the location means comprises a radio receiver that is adapted to receive signals from a plurality of satellites and thereby determine the location of the equipment.

44. Mobile agricultural treatment equipment comprising treatment apparatus that is adjustable to vary a treatment value characterised in that the equipment is provided with location means to identify the location of the equipment in a field, and programmable control means that is responsive to operation of said location means in accordance with a predetermined treatment programme comprising a map of treatment values in a field to be treated, the programmable control means determining the treatment value for the treatment apparatus as it traverses the field.

45. Equipment as claimed in claim 44 in which the location means identifies the location of a boundary between adjoining patches of the field and controls the programmable control means so that the latter sets the treatment value associated with the next patch to be treated as the equipment crosses said boundary.

46. Equipment as claimed in claim 44 or 45 in which the location means operates by direct reference to independent datum means.

47. Equipment as claimed in claim 48 in which the location means comprises a radio receiver that is adapted to receive signals from a plurality of satellites and thereby determines the location of the equipment.

Printed for Her Majesty's Stationery Office by
Croydon Printing Company (UK) Ltd, 12/86, D8817356.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.